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Pedicled Sensate Composite Calcaneal Flap to Achieve Full Weight-Bearing Surface in Midshaft Leg Amputations: Case Report

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ABSTRACT

Of the possible levels of amputation, transtibial amputations result in functionally excellent outcomes. However, in contrast to hind foot amputations, such as Syme and especially Boyd amputation, acute or late complications related to the amputated stump are frequent with the various described techniques. The aim of this study was to describe a hind foot (including the calcaneum and fat pad) pedicled sensate flap with a surface that allowed full terminal weight-bearing in transtibial amputations in adults. One male patient, 66 years old with schizophrenia and chronic distal tibial osteomyelitis, underwent a leg amputation with sensate composite calcaneal flap construction. The stump was painless and able to bear total terminal weight at 12 weeks. Calcaneum tibial fusion was observed at 12-week postoperative follow-up. A below-knee prosthesis was adapted in 12 weeks, and at the 1-year follow-up, the patient was completely satisfied with the functional performance of his stump. The flap described provides proprioceptive feedback with the best bone and skin to support weight bearing. Another advantage is the possibility to use the same prosthesis commonly used in Boyd or Syme amputation due a longer arm leverage, which also allows full terminal weight-bearing. In the current study, a transtibial amputation covered with a pedicled sensate plantar flap preserving the calcaneum was proposed. In theory, the anatomic structures spared in this technique provide a strong full weight-bearing terminal surface of the stump that will last a lifetime.

KEYWORDS: Heel, extremities, leg

Amputations, especially of the lower limbs, are among the most ancient surgical procedures and give good functional results under the correct indications. Despite modern reconstruction techniques and replantation, the preservation of a severely traumatized limb, or even a limb affected by a congenital malformation, usually gives poorer functional results compared with amputation and prosthetization.[1]

Of the possible levels of amputation, transtibial amputations result in functionally excellent outcomes. However, in contrast to hind foot amputations, such as Syme and especially Boyd amputation, acute or late complications related to the amputated stump are frequent with the various described techniques.[2] Most techniques leave the medullary canal open, resulting in the loss of intraosseous pressure, which can alter

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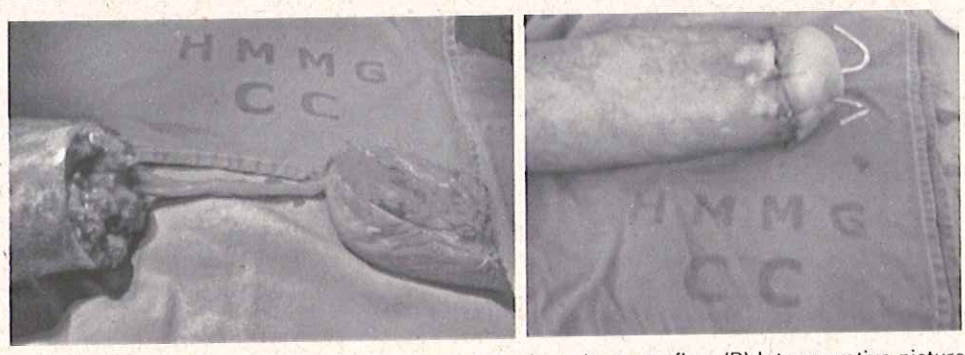


Figure 1 (A) Intraoperative picture showing the sensate composite calcaneum flap. (B) Intraoperative picture showing the calcaneum flap fixation to the distal tibia.

endosteal vascularization. In painful stumps that need revision, loss of the distal synostosis is common; this evolves with the approximation between the bones, funneling the extremity and allowing posterior migration of the cushion, which usually prevents functional prosthesis adaptation.[3]

In 1949, Ertl described a surgical technique that restored the interosseous pressure through canal obliteration and expanded the area of terminal support by forming a bony bridge between the fibula and distal tibia, similar to Boyd amputation, but without the calcaneum and the fat pad.[4]

The aim of this study was to describe a hind foot (including the calcaneum and fat pad) pedicled sensate flap with a surface that allows full terminal weight-bearing in transtibial amputations in adults.

PATIENT AND METHODS

Patient

One male patient, 66 years old with schizophrenia and chronic distal tibial osteomyelitis, underwent a leg amputation with sensate composite calcaneal flap construction.

Surgical Technique

The sensate composite calcaneal flap should be fixed as far distally as possible. The surgical procedure began with a medial longitudinal ankle incision to identify and isolate the posterior tibial neurovascular bundle, which was dissected proximally (until the tibial osteotomy level) and distally including the calcaneum, heel fat pad, and as much foot sole as possible. Then a midfoot disarticulation at Chopart's joint was performed, as described by Boyd, with talectomy and calcaneum articular cartilage surface removal.

The midshaft tibial osteotomy was performed, and the distal flap was still perfused and innervated by the intact posterior tibial neurovascular bundle (Fig. 1A). To provide a tibial calcaneum fusion, the heel was fixed to the remaining tibial shaft by 2 smooth Steinmann pins (Fig. 1B). The neurovascular bundle remained intact.

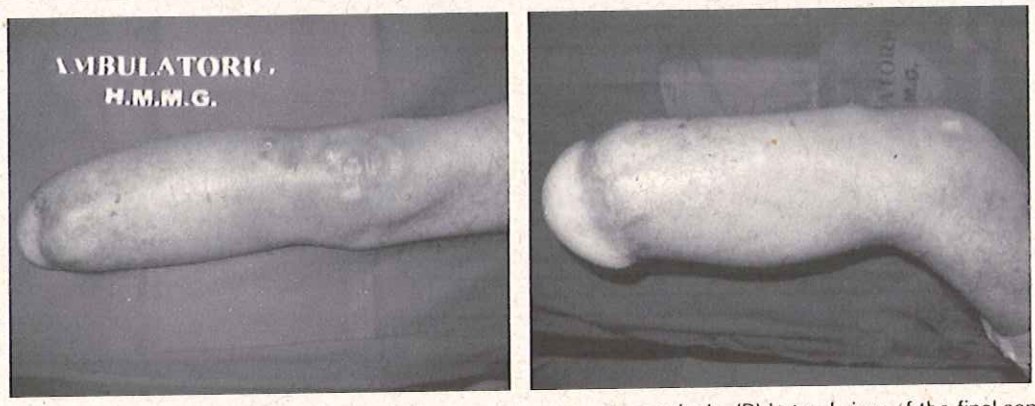
The subcutaneous tissue and the skin were closed with stitches and no suction drain was needed. A below-knee cast used for 12 weeks. Early knee motion is encouraged. The sutures were removed in 3 weeks and the Steimann pins in 12 weeks. Monthly radiographs were taken.

RESULTS

The intraoperative procedure had no intercurrences. The wound had no infection, and skin incisions healed without complications.

The stump was painless and able to bear total terminal weight in 12 weeks. Calcaneum tibial fusion was observed at 12-week postoperative follow-up (Fig. 2).

Figure 2 Radiograph showing solid fusion between distal tibia and calcaneum 12 weeks postoperatively.



A B

Figure 3 (A) Anterior view of the final aspect of the stump 1 year postoperatively. (B) Lateral view of the final aspect of the stump at 1 year postoperatively.

A below-knee prosthesis was adapted in 12 weeks, and at the 1-year follow-up, the patient was completely satisfied with the functional performance of his stump (Fig. 3A and 3B).

DISCUSSION

Generally, the quality of life of a lower-limb amputee with a functional stump is similar to that of an average person.[5] Consequently, a technically well-constructed stump must be the objective of the orthopedic surgeon. Unfortunately, many amputations are delegated to less experienced orthopedic surgeons or even to medical residents, which can lead to poor functional results, chronic stump pain, and prosthetization difficulties.[2] In the classical transtibial amputation, the fibula is osteotomized ~1 cm shorter than the tibia, avoiding the excessive concentration of pressure at this location during the gait after prosthetization. The common complications with this technique may require stump revisions and result in high late-morbidity rates.[6]

The initial amputation stump can be funnel shaped, which can cause pain and difficulty adapting to a prosthesis. The distal narrowing of the stump is caused by posteromedial migration of the fibula, which tends to medialize with weight-bearing, as it lacks a distal contention (i.e., the syndesmosis is lost). Given that pressure equals force divided by the area (i.e., $P = F/A$), a smaller stump area experiences greater pressure and is thus more likely to develop ulcers, late infection, and pain. Conversely, a larger area of support allows for a wider distribution of pressure, which reduces the likelihood of pain and increases the weight-bearing ability of the terminal stump. This is particularly important for meeting the greater functional demands in patients such as young people, athletes, military, and professionals who exert more physical effort.[7]

A change in the intraosseous pressure and the consequent reduction in perfusion result from an open distal tibia and can cause stump pain.[8] In addition, a delay in or absence of the use of a stump can lead to progressive osseous demineralization (nonuse osteoporosis), which is generally painful; the pain further reduces stump use, leading to a vicious cycle that incapacitates the patient. Often, socioeconomic difficulties result and an associated depression develops. The sooner the patient returns to a daily routine, the greater are the chances of socioeconomic readaptation.[9]

Ankle disarticulations provide a durable end-bearing stump. In 1843, Syme described an amputation consisting of a bone section at the distal tibia and fibula 6 mm proximal to the periphery of the ankle joint. The tough, durable skin and fat pad of the heel flap provides normal weight-bearing skin. The most common cause of an unsatisfactory Syme stump is posterior migration of the heel pad.

The Boyd amputation produces an excellent end-bearing stump around the ankle and eliminates the problem of posterior migration of the heel pad and also provides a stable stump with an intact proprioceptive sensation. This procedure involves talectomy, forward shift of the calcaneus, and calcaneotibial arthrodesis.[10]

When classical transtibial amputation is performed, skin complications such as wound breakdown and development of ulcers and callosities over a disarticulated stump may occur because of the concentration of pressure to the small weight-bearing stump and a shortage of soft tissue to cover the stump. These complications often prolong the patient's hospital stay and prevent early aggressive rehabilitation with prosthesis. To overcome this problem, a greater weight-bearing area and sufficient soft tissue coverage are desirable.[3]

In 1949, Ertl described an amputation technique using a bony bridge that, in theory, dealt with all of the inconveniences of the conventional transtibial amputation mentioned above. This procedure closes the medullary canal with cortical bone, which restores the intraosseous pressure, blood flow, and vascularization.[5] The resulting bony bridge increases the terminal area of the stump, makes it more stable, and avoids the posteromedial migration of the fibula and the consequent

funneling. A larger base distributes the weight over a wider area, reducing the pressure.[11]

In 2002, Weber described a new technique to perform a capping of the distal tibia with neurovascular calcaneocutaneous pedicle flap in congenital pseudarthrosis of the tibia in children. In that article, the author had not performed any of these procedures in adults but recommended segmental resection of vascular bundle and terminal anastomosis because adults lack vessel elasticity to allow loop arrangement and vein thrombosis or arterial occlusion might occur.[12]

We performed a pedicle sensate composite calcaneal flap to achieve full weight-bearing surface in midshaft leg amputations in an adult patient. Although the neurovascular remained redundant, the flap perfusion was completely normal during the entire procedure; therefore, we decided to perform a pedicle flap instead of a segmental vessel resection and microvascular reconstruction. The procedure had no complications even without vascular bundle resection despite the vessels looping.

The flap described provides proprioceptive feedback with the best bone and skin to support weight bearing. Another advantage is the possibility to use the same prosthesis commonly used in Boyd or Syme amputation due a longer arm leverage that also allows full terminal weight-bearing. The obvious disadvantage of this procedure is that amputation technique is only possible when the patient has a healthy calcaneum and heel pad.

In the current study, a transtibial amputation covered with a pedicled sensate plantar flap preserving the calcaneum was proposed. In theory, the anatomic structures spared in this technique provide a strong, full weight-bearing terminal surface of the stump that will last a lifetime.

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